OBSERVATIONS AT HONOLULU.

Through the kind cooperation of Mr. Curtis J. Lyons, Meteorologist to the Government Survey, the monthly report of meteorological conditions at Honolulu is now made nearly in accordance with the new form, No. 1040, and the arrangement of the columns, therefore, differs from those previously published.

Meteorological observations at Honolulu, July, 1899.

The station is at 21° 18′ N., 157° 50′ W.
Pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.
The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force or amounts of cloudiness, connected by a dash, indicate change from one to the other.
The rainfall for twenty-four hours has always been measured at 7:30 p. m., not 1 p. m., Greenwich time, on the respective dates.
The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet, and the barometer 50 feet above sea level.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m., Greenwich time, or 2:30 a. m., Honolulu time.									Total rainfall at 9 a. m., local time.
		Dry bulb.	Wet bulb.	Temperature. Maximum.	Temperature. Minimum.	Means. Dew-point.	Means. Relative humidity.	Wind. Prevailing direction.	Wind. Force.	Average cloudiness.	Sea-level pressures. Maximum.	Sea-level pressures. Minimum.	
	*	†	†			‡	‡		§				
1	29.89	65	63	82	67	61.5	68	nne.	3-4	1	29.98	29.89	0.00
2	29.87	67	65	84	63	63.7	73	s-w-ne.	0-1	5	29.92	29.82	0.00
3	29.93	71	68	85	66	67.0	76	s-w-e.	0-1	1-9	29.96	29.88	0.00
4	29.98	74	67	84	68	65.7	68	ne.	3	1-3	29.99	29.93	0.00
5	29.93	74	66	82	74	65.5	71	ne.	3	4-8	30.03	29.93	0.10
6	29.90	72	65.5	81	70	63.7	66	ne.	3	5	29.98	29.90	0.04
7	29.92	74	65.5	82	70	62.0	63	nne.	3	2-4	29.95	29.88	0.01
8	29.98	75	68	83	73	61.7	60	ene.	3	3	30.01	29.91	0.01
9	30.01	75	69.5	84	73	64.2	65	ne.	3	7-3	30.06	29.97	0.05
01	29.99	75	69	82	72	66.5	69	ene.	3-5	8	30.05	29.99	0.00
11	30.00	73	69.5	84	75	66.2	68	ene.	3	7	30.06	29.98	0.01
12	29.95	73	66	83	71	64.2	67	nne.	3	2	30.03	29.95	0.05
13	29.97	67	63	85	65	61.2	60	e-n.	1	3	29.99	29.91	0.00
14	29.98	67	64	84	65	63.7	67	sw.	1	4	30.01	29.95	0.00
15	29.96	74	70.5	87	66	65.2	69	s-ne.	0-2	0-6	30.01	29.93	0.00
16	29.97	74	69.5	87	74	70.2	76	ne.	2	7-2	30.01	29.92	0.00
17	30.00	77	70	86	70	67.7	64	ne.	3	3	30.03	29.94	0.00
18	30.01	76	67.5	86	77	66.5	66	nne.	1-3	7-2	30.06	30.00	0.00
19	29.99	76	67	85	75	62.3	58	ne.	2-4	4-8	30.08	29.99	0.00
20	30.00	74	67	84	75	63.5	64	ene.	3	6	30.06	29.98	0.00
21	29.97	72	67.5	83	74	64.3	66	ene.	3	5	30.05	29.96	0.06
22	29.96	75	68	83	71	64.5	70	ene.	3-5	4	30.02	29.91	0.01
23	29.96	75	67.5	84	74	63.3	62	ene.	3	3	30.00	29.92	0.03
24	29.94	74	68.5	82	72	63.5	65	ne.	3	4	30.00	29.92	0.00
25	29.90	72	68.5	85	73	65.0	65	nne.	2	2-6	29.97	29.90	0.02
26	29.91	74	70	85	71	67.5	71	ne.	3	6	29.92	29.85	0.00
27	29.93	75	69	87	71	67.5	69	ne.	2	4-1	29.97	29.90	0.00
28	29.98	76	69	86	74	68.5	70	ene.	3	5	30.08	29.93	0.02
29	29.97	75	68.5	84	75	65.0	63	ne.	2-4	3-1	30.03	29.95	0.00
30	29.95	75	68.5	84	74	65.7	67	nne.	3	2-5	30.02	29.92	0.00
31	29.96	74	67	84	74	65.3	65	ne.	3	6	30.00	29.92	0.01
Sums.	......	......	......	......	......	......	......	......	......	......	......	......	0.42
Means.	29.96	73.2	67.5	84.1	71.7	64.9	66.6	......	......	4.2	30.009	29.927	......
Departure.	—.015	......	......	......	......	......	—3.0	......	0.0	0.0	......	......	—1.60

Meteorological observations at Honolulu, August, 1899.

Date.	Pressure at sea level.	Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.	Average cloudiness.	Maximum.	Minimum.	Total rainfall at 9 a. m., local time.
	*	†	†			‡	‡		§				
1	30.00	75	69	85	73	64.5	64	ne.	3	4	30.04	29.94	0.08
2	29.96	75	72	85	71	67.5	71	ne.	4-0	2-5	30.01	29.98	0.11
3	29.94	76	70	86	72	70.3	76	ne.	2-4	4-2	30.00	29.92	0.19
4	29.93	75	69.5	84	73	67.3	71	ne.	3	4-2	29.98	29.91	0.00
5	29.92	76	68	85	74	67.3	69	ene.	3	5-8	29.96	29.89	0.01
6	29.98	75	68	85	76	66.0	66	ene.	3	7	30.00	29.92	0.00
7	30.01	76	70	85	75	64.0	62	ne.	4	7-2	30.04	29.98	0.00
8	29.99	75	68.5	82	75	69.2	76	ene.	1-3	9-4	30.04	29.98	0.28
9	29.98	75	68	84	75	65.2	64	ne.	2-5	2	30.08	29.93	0.01
10	29.94	75	67.5	82	74	67.1	78	ne-nne.	3-5	6	30.00	29.92	0.08
11	29.94	74	68	83	72	64.5	64	ene.	4	4-8	29.99	29.94	0.10
12	29.95	75	68.5	84	71	66.0	68	nne.	3-1	5	30.01	29.94	0.06
13	29.96	75	67	84	74	65.7	67	ne.	3-5	4	30.02	29.95	0.03
14	29.96	75	68	84	75	64.3	63	ne.	4	5	30.01	29.95	0.07
15	29.96	74	69	83	73	64.7	65	ne.	4	6	30.01	29.94	0.20
16	30.00	74	69	83	71	65.7	69	ne.	4	4-8	30.02	29.94	0.14
17	29.96	75	67.5	83	72	66.3	72	ene.	5	8	30.05	29.96	0.02
18	29.93	75	67.5	84	74	64.7	63	nne.	5	4	30.00	29.92	0.00
19	29.94	75	67	84	74	64.5	63	nne.	5	2	29.99	29.91	0.00
20	29.96	71	66	84	75	64.0	62	nne.	4	2	29.99	29.90	0.00
21	29.95	75	69	85	70	63.7	64	nne.	3	4-1-5	29.99	29.90	0.01
22	29.94	74	68.5	84	75	67.7	73	ne-e.	3	9	29.98	29.91	0.06
23	29.93	74	66.5	82	74	67.0	76	ene.	4	9-7	29.98	29.91	0.02
24	29.94	74	67	83	74	62.7	61	nne.	3	4	29.99	29.90	0.00
25	29.97	75	66.5	84	73	63.3	61	ne.	4	3	30.00	29.94	0.01
26	29.98	74	68.5	83	74	63.5	62	ne.	4-5	4	30.01	29.94	0.09
27	29.96	74	67	83	73	65.3	68	ene.	3	7-3	30.04	29.95	0.01

Meteorological observations at Honolulu, August, 1899—Continued.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 2:30 a. m., Honolulu time.									Total rainfall at 9 a. m., local time.
		Dry bulb.	Wet bulb.	Temperature. Maximum.	Temperature. Minimum.	Means. Dew-point.	Means. Relative humidity.	Wind. Prevailing direction.	Wind. Force.	Average cloudiness.	Sea-level pressures. Maximum.	Sea-level pressures. Minimum.	
	°	†	†			‡	‡		•				
28	29.90	68	64.5	85	74	63.7	68	ne.	3-0	3-1	29.98	29.88	0.00
29	29.89	70	66.5	86	67	64.0	66	nne.	2-0	1	29.92	29.79	0.00
30	29.94	74	69.5	86	68	66.7	71	s-nne.	0-3	6-1	29.96	29.85	0.00
31	30.00	76	68.5	85	72	67.0	69	ene.	3	3	30.04	29.94	0.00
Sums.	......	......	......	......	......	......	......	......	......	......	......	......	1.53
Means.	29.96	74.3	68.1	84.0	73.0	65.6	67.3	......	3.3	4.5	30.00	29.92	....
Departure.	—0.01	......	......	—0.3	—0.3	......	—1.3	......	......	+0.5	......	......	—0.50

Mean temperature for July, 1899 (6+2+9) ÷ 3=77.0°; normal is 77.3°. Mean pressure for July (9+3) ÷ 2 is 29.970; normal is 29.995.
* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4:30 p. m., Greenwich time. ‡ These values are the means of (6+9+2+9) ÷ 4. § Beaufort scale.

Mean temperature for August, 1899, (6+2+9) ÷ 3=77.3°; normal is 77.6°. Mean pressure for August (9+3) ÷ 2 is 29.96; normal, 29.98.
* This pressure is as recorded at 1 p. m., Greenwich time. † These temperatures are observed at 6 a. m., local, or 4:30 p. m., Greenwich time. ‡ These values are the means of (6+9+2+9) ÷ 4. § Beaufort scale.
On the 24th earthquakes reported at Hilo, Hawaii, and Tanoke, over Mauna Loa.

AUTOMATIC RECORDS OF A THUNDERSTORM.

By H. H. KIMBALL, Weather Bureau.

On the afternoon of August 2, 1899, a severe thunderstorm, accompanied by destructive winds and hail, passed over the District of Columbia and the adjacent counties of Maryland. The center of its path, and also the region experiencing the greatest destructive effect, were a few miles to the east of Washington. The Central Office of the Weather Bureau did not, therefore, feel the full force of the storm; but the records obtained from some of the automatically recording instruments in operation in the Instrument Division are believed to be of sufficient interest to warrant their reproduction.

All recording instruments employed by the Weather Bureau are furnished with pens in which a purple aniline ink is used. This color prevents the direct reproduction of records by photographic processes. Blank record sheets were, therefore, superimposed over the sheets containing the instrumental records of this storm, and the records were traced in by hand with india ink. Full size photo-engravings of these traced records were then obtained, from which the diagrams on Fig. 1, page 357, were printed.

Full descriptions of most of the instruments employed may be found in Circulars D, E, F, and G, Instrument Division, and also in Part I, Report of the Chief of the Weather Bureau, 1891–1892.

The following brief description of the records, and the manner in which they are obtained, is for the benefit of those not familiar with the instrumental equipment of Weather Bureau stations.

On Fig. 1 the record marked *A* is from the so-called quadruple register, sometimes called the triple register, in general use at stations. The record is in four parts designated *a*, *b*, *c*, and *d*.

The part of *A*, designated *a*, represents the direction from which the wind was blowing, and is obtained by means of four automatic circuit closers attached to a rod that turns with the wind vane. A "minute contact" on the register clock completes the circuit through the proper magnet or magnets, and the corresponding direction is marked on the record sheet by printing arms attached to the magnet armatures.

The part of A, designated b, shows the velocity of the wind as indicated by a Robinson anemometer exposed 39 feet above the roof of the Weather Bureau building. Five hundred revolutions of the anemometer cups, which are mounted on arms 6.72 inches long, are supposed to represent one mile of wind. A pin on a dial wheel depresses a contact spring and closes an electric circuit at the end of each 500 revolutions, causing the register pen, which is attached to the magnet armature, to make a short offset from its normal trace. The ninth and tenth pins are connected by a bridge, so that from the beginning of the ninth to the end of the tenth contact a continuous offset is made, and the mile record marks are divided off into groups of ten. The recorded miles per hour can, if desired, be converted into true miles per hour by a table in the circular D above mentioned.

The part of A, designated c, represents the duration of sunshine, and the record is obtained by means of a differential air thermometer, the effect of sunshine being to heat and expand the air in the black bulb of the thermometer more than in the bright bulb, causing a mercurial column to rise and close a circuit that is completed each minute by the register clock. A suitable cam wheel causes the pen attached by an arm to the magnet armature to take successively five steps in one direction, and then a like number in the other.

The part of A, designated d, is the rainfall record from the tipping-bucket gage, a bucket with two compartments being pivoted under the funnel-shaped collector of the gage so that it tips for each .01 inch of rain collected, and each tip of the bucket closes the circuit through the same magnet that actuates the sunshine-record pen.

We thus obtain from this one register continuous records of the direction and velocity of the wind, the duration of sunshine, and the amount and rate of rainfall.

B, Fig. 1, is the wind velocity recorded by the Richard Brothers' anemo-cinemograph, which is actuated by the same anemometer that gave us b, described above. For this record, however, the circuit through the magnet is closed for every six and a quarter revolutions of the anemometer cups. Each movement of the magnet armature raises the pen a short distance on the record sheet. A clock movement, controlled by a governor working in sympathy with the magnet armature, tends constantly to carry the pen toward the bottom of the sheet. A perfectly steady wind of, say, 25 miles per hour, would cause the pen to rise to the twenty-fifth line on the sheet, maintain its position, and produce a straight longitudinal trace. A variable wind would keep the pen rising and falling between the lines representing its maximum and minimum velocities.

C, Fig. 1, is the temperature record made by a Richard Brothers tele-thermograph. The thermometer bulb employed is a Baudin pressure tube filled with alcohol. A change in temperature produces a slight movement in the free end of the bulb, which movement is magnified by means of levers and employed to close circuits through magnets on the register, which operate the recording pen. The pen moves by intervals of a half degree Fahrenheit.

D, Fig. 1, represents the pressure changes recorded by Professor Marvin's normal mercurial barograph, having a barometer tube suspended from the short arm of a balance beam. A change in the air pressure causes a slight movement of the beam, thereby closing an electric circuit. The movement of the magnet armature turns a screw and shifts a weight on the long arm of the beam, and the movement of this weight, which restores the equilibrium of the beam, is recorded by a pen; each movement of the weight or pen represents a change in air pressure of .0001 inch.

E, Fig. 1, is a record of the rainfall from Professor Marvin's weighing rain and snow gage. The rain falling into a collector 8 inches in diameter flows into a receiver resting on a balance, and the counterpoise on the arm of the balance is moved electrically for every .001 inch of rainfall. The recording pen is made to move simultaneously with this weight when a double-threaded screw is turned by the motion of the magnet armature on the register, and the thread of the screw advances the pen either down or up the record sheet, depending upon the amount of rain that has fallen. Once across the sheet represents .50 inch of rainfall. The longitudinal traces numbered 29, 30, 31, and 1 indicate the absence of rainfall on the four days preceding August 2.

The time scales are all plainly marked on the record sheets, except in the case of A. Here the double lines numbered 3, 4, 5, and 6, near the top and bottom, represent, respectively, 3 p. m., 4 p. m., and 5 p. m. The figures 9, 10, 11, and 12 midnight belong to a wind direction record made six hours later than that here given, and which was cut out, as not being necessary to the history of this storm. The scales for wind velocity, temperature, pressure, and rainfall, are also plainly marked on B, C, D, and E, respectively.

There is always a time error in the records, just as there is in a watch or clock, but it is not so easily determined. This time error is partly due to the rather cheap grade of clock movements employed, partly to errors in setting the pens, and partly to imperfect connections between the clock movements and the register cylinders.

It is customary to make a "time record" at some convenient hour on most instruments, but this is not done in the Instrument Division, since the instruments are kept in operation mainly for experimental and exhibition purposes. The Forecast Division has a complete set of instruments from which the official records for Washington are taken. All the pens were set at noon of August 2, except the tele-thermograph pen, C. The clock on this instrument was gaining rapidly, and the pen was probably thirty minutes fast.

By a slight defect in the register, the wind direction printing points and the sunshine and rainfall recording pen on the quadruple register were thrown about two and a half minutes ahead of the wind velocity pen. This latter, and the pen on the anemo-cinemograph were about three minutes faster than the official wind record for Washington, which, together with D and E, are assumed to have been recorded correctly on standard eastern time.

Making allowances for the time errors of a, b, c, d, B, and C, the records give us the following history of the thunderstorm of August 2.

Previous to the storm the general direction of the wind was from the south, a, the velocity averaging about 15 miles per hour, b and B, and increasing gradually; B brings out very clearly the characteristic irregularities in its velocity.

The sun was shining from 2:25 p. m. to 3:06 p. m., and during this time the maximum temperature of the day, 89°, occurred, C. The record of a maximum recording thermometer shows that the tele-thermograph was reading 1° low at this time. Cloudiness prevailed after 3:06 p. m., and the temperature fell slowly. The pressure was decreasing rapidly, D.

At 4:25 p. m. there was a diminution in the velocity of the wind, followed at 4:32 by a sudden gale that reached an extreme velocity of 1 mile in sixty-five seconds, or 55 miles per hour at 4:35 p. m., b, or 47 miles per hour by the anemo-cinemograph record, B.

The wind direction backed from the south to southeast, east, northeast, north, and northwest, between 4:29 p. m. and 4:38 p. m., after which it veered to the north, northeast, and east, a.

Simultaneously with the commencement of the gale the temperature began to fall rapidly, a change of 15° being recorded in about five minutes, C.

Three barographs, in addition to the Marvin normal barograph, were in operation at the Central Office at this time,

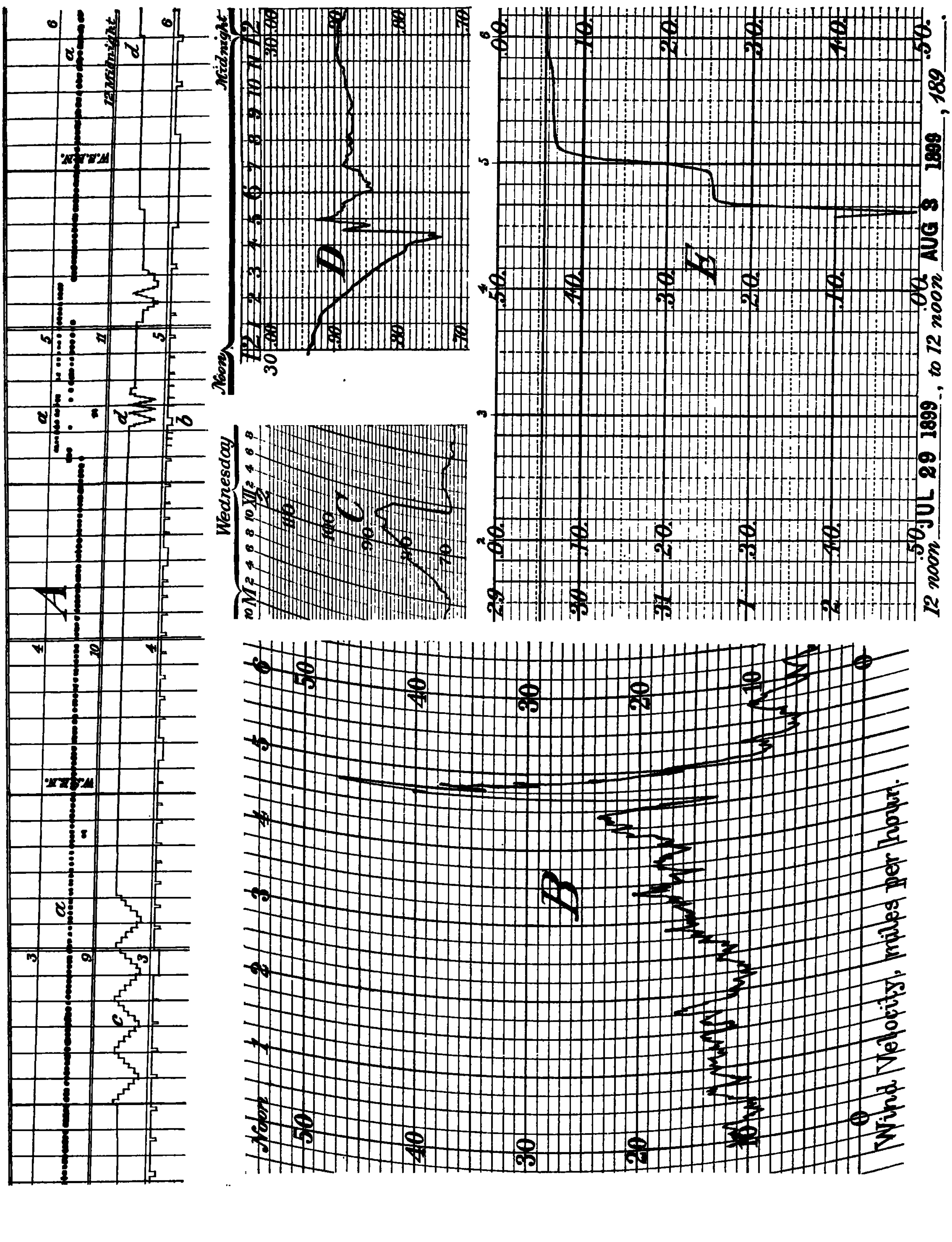

FIG. 1.—Automatic records of the thunderstorm August 2, 1899, at Washington, D. C.

and they all agree in showing the occurrence of the minimum pressure in advance of the storm, and at about 4:20 p. m., as shown at *D*. A very rapid increase in pressure commenced at 4:27 p. m., the recorded increase being at the rate of .10 inch in three minutes, which is as fast as the electrical mechanism can move the pen.

Rain commenced to fall at 4:35 p. m., *E* and *d*. A rate of .05 inch per minute was maintained for six minutes, after which the rate was quite irregular. Rain did not entirely cease until 6:12 p. m. The total amount was .50 inch by *d*, and .554 inch by *E*. This discrepancy is partly due to the differences in the exposure of the two gages, but largely to the fact that during a very rapid rate of rainfall the time it takes the bucket of the tipping-bucket gage to tip introduces an error in the recorded amount. On this occasion the rainfall collected in the gage was .53 inch by stick measurement against .50 inch recorded.

A large discrepancy has been noted in the extreme velocities recorded by the anemo-cinemograph and the quadruple register, i. e., 47 and 55 miles per hour, respectively. The quadruple register can do no more than show the time taken by the anemometer cups to make each successive 500 revolutions. The wind velocity must vary considerably during these intervals, and we thus fail to record the highest velocity attained, which may have been maintained a few seconds only. When we remember that the pressure of the wind varies with the square of the velocity, we see how desirable it becomes that we be able to measure these extreme velocities, even though they are of such short duration.

The following experiment was made in order to determine the sensitiveness of the Richard register. It was disconnected from the anemometer and the pen finally came to the zero velocity line on the sheet. The magnet armature was then operated by hand at the rate of eighty closures of the circuit per minute, which corresponds to a wind velocity of 60 miles per hour. After nine minutes this movement of magnet armature ceased. In the following table the second column shows the wind velocity indicated by the recording pen at the end of each minute after the commencement of the magnet armature movement, and the third column the indicated velocity at the end of each minute after the armature movement ceased.

Test of sensitiveness of Richard Brothers' anemo-cinemograph.

Time.	Indicated velocities.	
	80 armature movements per minute.	Armature at rest.
Minutes.		
0	0	58
1	19	39
2	32	27
3	41	18
4	46	12
5	50	8
6	53	6
7	55	4
8	57	3
9	58	2

This experiment shows that should a 60-mile gale spring up suddenly from a dead calm and prevail for four minutes, the instrument would only record 46 miles per hour. Or if the wind suddenly sprang from a 19-mile breeze up to a 60-mile gale and prevailed for four minutes as before, 50 miles per hour would be recorded.

It was under conditions somewhat like these that *B* was produced. The wind increased suddenly from 13 to 50 miles per hour, *b*, maintained this average for five minutes, reaching in this interval a momentary velocity of at least 60 miles per hour, then diminished to 26 and finally to 4 miles per hour.

The superiority of the Weather Bureau register under such conditions is manifest.

The recording mechanisms of the rain gages are capable of following any rate of rainfall we may expect, excepting the resulting error in the record from the tipping-bucket gage, already noted.

The same is true of the tele-thermograph with respect to temperature changes; but the latter instrument can not follow sudden temperature changes perfectly, on account of the slowness of the bulb to attain the temperature of the surrounding medium. Just what may be expected of the instrument is shown by the following readings made on a thermograph recording mechanically instead of electrically, but having a bulb similar to that on the tele-thermograph. The thermograph was suddenly subjected to a change in temperature of about 40° F., and the air was kept in motion by an electric fan. Although the instrument shelter may never be quite so well ventilated as to admit of an air circulation equivalent to that maintained during these experiments, yet the ventilation must have been very good during the high winds that accompanied the storm of August 2. The fall in temperature was not so rapid, however, as was observed during these experiments.

Test of sensitiveness of thermograph bulb.

Time.	First experiment.	Second experiment.	
	Thermograph readings.	Mercurial thermometer readings.	Thermograph readings.
Seconds.	°	°	°
0	113.0	106.0	106.0
5	107.0	99.0	101.0
10	101.5	93.0	97.0
15	97.0	90.0	93.0
20	92.5	86.5	90.0
25	89.5	84.0	88.0
30	86.5	82.0	85.5
35	84.0	80.0	84.0
40	82.0	78.0	82.0
45	80.5	77.0	80.5
50	79.0	76.0	79.0
55	77.5	75.0	78.0
60	76.5	74.2	77.2
65	75.5	73.5	76.5
70	75.0	73.0	76.0
75	74.2	72.8	75.2
80	73.5	72.3	74.5
85	73.0	72.0	74.0
90	72.6	71.7	73.7
95	72.2	71.5	73.4
100	72.0	71.2	73.0
105	71.6	71.0	72.8
110	71.4	71.0	72.5
115	71.2	71.0	72.4
120	71.0	71.0	72.3
125	70.8	71.0	72.1
130	70.6	71.0	72.0
135	70.5	71.0	71.8
140	....	71.0	71.7
145	....	70.8	71.6

The automatic records of the storm of August 2 substantiate most beautifully Professor Davis's explanation of the cause of the increase in the air pressure in front of a thunderstorm. (See Elementary Meteorology, Davis, pp. 263–4, Fig. 100.)

We have already stated that the storm approached Washington from the north. It passed off to the southeast, only its edge extending over the city.

The south wind that prevailed up to 4:29 p. m. was, therefore, a *warm inflowing wind*.

At this time the air pressure, which some minutes previously became nearly stationary, had commenced to increase rapidly, and the wind began to back around to the north, the reversal of direction being completed in three minutes. A *cold outrushing wind* then prevailed at the surface. The rain soon followed the squall and the wind gradually became light, but continued to blow out from the storm until after the rain had ceased.